# Enhancement of Runaway Avalanche by Lower Hybrid Waves

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The ‘‘knock-on’’ source is a key ingredient of secondary electron generation by runaway avalanche. The avalanche depends on the existence of some trace amount of very energetic electrons (MeV and above) in the plasma. These electrons can knock out bulk electrons to super-critical energies through large angle scattering. In the presence of an electric field, they become runaways and can positively feedback on the knocking-out of more bulk electrons. This process is different from the Dreicer runaway mechanism by the much smaller threshold electric field $E_{\mathrm{c}}$ (smaller than the Dreicer field $E_{\mathrm{d}}$ by $v_{\mathrm{t}}^2 / c^2$). However, for electric fields close to the threshold value, it takes a long time for the avalanche process to build up hence difficult to realize. The lower hybrid waves, even when the minimum phase velocity of the spectrum is significantly larger than the thermal velocity, can effectively pull out a non-thermal tail thereby aiding the electric field and shortening the time for the avalanche process. This work presents the first demonstration by numerical solution of the Fokker-Planck equation including large angle Coulomb scattering that significant enhancement of the runaway production rate is possible. When the self-consistent evolution of the electric field is taken into account, a long lasting non-inductive current carried mainly by runaway electrons can be set up with high current drive efficiency. This also presents an alternate explanation to the long-standing spectral gap problem in lower hybrid current drive experiments. Comparison with theoretical expectations will be discussed.

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